NETL's NOx Control Program

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Summary

The U. S. Department of Energy (DOE) has established a set of national priorities through its Strategic Plan that includes the goal to promote secure, competitive, and environmentally responsible energy systems that serve the needs of the public. To achieve this goal, the Innovations for Existing Plants program (IEP), managed by the DOE's National Energy Technology Laboratory (NETL), develops advanced, low cost, environmental control technologies for coal-based power systems. The program also provides high-quality scientific information on present and emerging environmental issues for use in regulatory and policy decision-making.

An important component of the IEP program is the research and development of advanced nitrogen oxide (NOx) control technologies. This effort is focused primarily on systems capable of controlling NOx emissions to a level at or below 0.15 lb/MMBtu at a cost significantly lower than today's state-of-the-art technology. The corresponding projects also provide an improved understanding of the impact of these advanced technologies on related issues such as unburned carbon, waterwall wastage, and mercury speciation and capture. The research is driven by continuing pressure for further reductions in NOx emissions from coal-fired utility boilers to address ground-level ozone and other environmental considerations including ambient fine particulates, visibility, eutrophication, climate change, as well as "acid rain" precursors.

NOx R&D Program

Building upon the successes of the Clean Coal Technology and the Advanced Research and Environmental Technologies programs, the IEP program continues the research, development, and demonstration of advanced NOx control technologies. A key to the success of the NETL NOx technology research is the close coordination and cooperation with industry. As a result, the programs have had a strong history of assisting in the development of useful commercial products, such as low NOx burner (LNB) technology. The introduction of advanced NOx control technology such as LNBs has helped to significantly reduce the emission of NOx from coal-fired power plants on a pound per million Btu basis.

In continuing these efforts, NETL is currently managing a portfolio of NOx control technology R&D projects ranging from laboratory studies to modeling to full-scale demonstration. The technologies being addressed include ultra low NOx burners, advanced reburning, selective non-catalytic reduction (SNCR), selective catalytic reduction (SCR), METHANE de-NOx, and oxygen-enhanced combustion. These projects represent the collaborative effort of over a dozen industrial and academic organizations.

NOx Control Technologies

Regulatory requirements for controlling NOx emissions from steam-electric power plants are advancing at a rapid pace. To date, the workhorse in minimizing the NOx component of acid rain has been modified combustion technologies that include LNBs, reburning, and other in-boiler combustion methods. However, proposed regulations that address issues pertaining to ground-level ozone and other environmental considerations including ambient fine particulates, visibility, and eutrophication will demand higher performance combustion modifications or may require post-combustion controls to

further reduce NOx emissions.
Complicating the NOx control issue is the fact that today's power generators can be characterized as having a diverse configuration of boiler types and firing methods with plant ages ranging from one to five decades and plant operating dispatch roles ranging from cycling to base-load. Uncertainty over the availability of a reliable suite of NOx emission control systems that can be retrofitted to the various boiler types and their respective modes of dispatch at an acceptable cost is of concern. To satisfy the economic pressure for low-cost power, these power plants require a portfolio of advanced control systems that have low capital and annualized costs and address site specific issues.

NETL is addressing this need for strategic research, development, and testing of efficient, cost-effective NOx control technologies, processes and concepts as noted on the above map to generate a portfolio that can be retrofitted to existing coal-fired electric utility boilers. The specific performance target is a NOx emission limit of 0.15 lb/MMBtu or lower while achieving a levelized cost savings of at least 25% over state-of-the-art control technology, which is defined as SCR. The levelized cost is based on uncontrolled NOx levels and includes the total cost of all NOx control systems required to achieve the emissions target of 0.15 lb/MMBtu. Further, the technologies under development are: (1) to have negligible impact on balance-of-plant issues; (2) applicable to a wide range of boiler types and configurations, and (3) capable of maintaining performance over a wide range of feed coals and operating conditions. The research portfolio includes advanced combustion controls, advanced flue gas treatment, and integrated control systems.

Project Summaries

Ultra Low NOx Integrated Systems for NOx Emission Control
Alstom Power is developing an ultra low NOx integrated system for coal-fired power plants that will achieve furnace outlet emission levels at or below 0.15 lb/MMBtu. The reduced NOx emissions will be obtained without increasing the level of unburned carbon (UBC) in the fly ash through advances in control systems, combustion process modifications, and post-combustion carbon burnout technology. The target market is tangentially fired (T-fired) coal boilers, which represent about 40% of the boilers currently listed in the State Implementation Plan (SIP) Call region.

NOx Control Options and Integration for U.S. Coal-Fired Boilers
Reaction Engineering International is optimizing the performance of the combined application of low NOx firing systems (LNFS) and post-combustion controls. The project will assess real-time monitoring equipment to evaluate waterwall wastage, soot formation, and burner stoichiometry. In addition, the impact of various coals on SCR catalyst activity will be investigated along with novel UBC/fly ash separation processes. The primary target of the research will be cyclone boilers, which represent about 20% of the U.S. generating capacity.

Cost-Effective Control of NOx with Integrated Ultra Low NOx-PC Burners and SNCR
In another advanced low NOx burner project, McDermott Technology and Fuel Tech are teaming to develop an integrated system comprised of ultra LNBs, coupled with SNCR. The overall goal of this project is to develop a cost-effective control system capable of achieving NOx levels below 0.15 lb/MMBtu for a wide range of coals. The primary market for the ultra LNB/SNCR technology are front- and opposed-wall-fired boilers within the NOx SIP Call region, with cell-fired, roof-fired, and arch-fired boilers also among the candidate boilers.

METHANE de-NOx for Utility Boilers
The Gas Technology Institute (GTI - formerly the Institute of Gas Technology and Gas Research Institute) is developing a pulverized-coal combustion system. The technology integrates natural gas-fired coal preheating, LNBs with internal combustion staging, and additional natural gas injection with overfire air. Preheating the coal promotes the conversion of fuel-bound nitrogen to molecular nitrogen rather than to NOx. GTI estimates the market for the technology to include more than 21,000 burners (over 260,600 MW) in the 37 eastern states encompassing wall-fired (wet- and dry-bottom), T-fired, roof-fired, and cell burners.

Oxygen-Enhanced Combustion for NOx Control
Praxair is developing oxygen-enhanced combustion and oxygen-enhanced reburning technologies for controlling NOx. Oxygen-enhanced combustion can be used to control both thermal and fuel NOx. The key to this project is the use of controlled conditions to take advantage of the combustion benefits of oxy-fuel firing to reduce NOx emissions below 0.15 lb/MMBtu.